

‘ΟΙ ΚΑΛΟΥΜΕΝΟΙ ‘ΑΡΜΟΝΙΚΟΙ: THE PREDECESSORS OF ARISTOXENUS

A cursory glance at the reports of the later students of harmonic theory is enough to give a clear if perhaps artificially systematic picture of the character and relations of the major conflicting schools of thought in the first century or so A.D. In the centre of the field are the supposed followers of Aristoxenus, lined up against the forces of the so-called Pythagoreans. Each side is linked with a more or less lunatic fringe; to the right of the Pythagoreans those mathematical extremists who find no place in harmonic studies for αἰσθησις at all, and to the left of the more empirical Aristoxeneans a collection of persons known as ὀργανικοί, whose work, whatever it was, is based wholly in perception and in familiarity with the properties of musical instruments, and who find no place for theory or for the pursuit of the αἰτίαι of harmonic truths.

Though Aristoxenus would have been horrified at some of the views espoused by his reputed followers, and though what came together under the title of ‘Pythagorean’ doctrine had many diverse sources, there is no doubt that at least a solid amount of what is attributed to these schools by such writers as Ptolemy and Porphyry quite genuinely goes back to the fourth century, to Aristoxenus on the one hand, and perhaps to Archytas and his followers on the other. It may be this fact that has tempted commentators to read back the line-up of forces which Ptolemy found in his day into the late fourth century itself. The picture presented is of Aristoxenus, himself a self-conscious innovator, in arms primarily against entrenched battalions of Pythagoreans, and occasionally hitting out in an incidental way at a relatively insignificant super-empiricist fringe to whose members he gives the name ἄρμονικοί.¹

I shall argue that this picture is quite wrong. Let us begin with the Pythagoreans, supposedly Aristoxenus’ principal opponents. It might perhaps be thought strange, but is not too surprising, that he never once mentions them by that name. There might be all sorts of reasons for that. It is possibly a shade more surprising that he never mentions by name any individual whom we could now recognise as a Pythagorean – Archytas, for example. Thirdly, we are entitled to wonder why, in stating those of his doctrines which plainly do run counter to Pythagorean positions, Aristoxenus fails to mention the fact that this conflict exists, and makes no attempt to explain it. As to explicit criticisms, out of the 35 or 40 passages in the *Elements* in which Aristoxenus directly attacks the views of contemporaries and predecessors, only one (32.20 ff.) is certainly directed against the Pythagoreans, and on my understanding of it only one other even might be. Finally, it seems odd, to

say the least, that in a number of passages Aristoxenus makes quite general claims about his predecessors' failure even to consider certain topics, when in several significant cases we have good evidence that Pythagorean theorists had already looked at them in some detail. These points must at least suggest that there is something amiss with the commonly imagined scenario of a fight to the death between Aristoxenus and the Pythagoreans. On the contrary, he seems largely to have ignored them.

On the other side, his complaints against the ἀρμονικοί, the more obviously empiricist school, are very frequent. But I shall argue that this is not to say that he regards them as representing a school of thought opposed to his own, or as some specially characterised group of eccentrics. He recognises, I believe, no special group of ἀρμονικοί out on the far left, from which he wishes to dissociate himself: rather, he gives the label ἀρμονικός to anyone whom he recognises as working in the same field as himself, and would, I think, have cheerfully accepted this appellation for himself. He criticises those who fall under this heading not as methodological heretics or eccentrics, but as having failed to do their work properly – work which he will now do much better. Of course, he may be quite wrong about this, rather as Aristotle has been criticised for seeing the Presocratics as trying and failing to be Aristotle: but for the present we are trying to see the relation as he himself perceived it.

I shall suggest that the reason why he has so little to say about the Pythagoreans is simply that he does not recognise them as attempting the same task. If their work – with which he was certainly familiar – is significant at all, it is so in a different field, and is not relevant to him. Thus his view of his own intellectual environment is entirely different from that of the historians of the Aristoxenean and Pythagorean schools of later antiquity, despite the fact that the basis of these latter accounts is quite genuinely to be found in the fourth century. There are even those in the fourth century itself whose understanding of the situation is not dissimilar: Theophrastus is conceivably a case in point.² But Theophrastus is not Aristoxenus.

The significance of these preliminary remarks will, I hope, come out in the sequel, since my object in this paper is to say something about the background of previous research against which Aristoxenus is working. In order to do this I must pursue this same theme a little further, with the aim of providing some evidence for the claims I have made so far: having done that I shall devote the remainder of the paper to the attempt to see what, if anything, can be said about the work of those whom Aristoxenus *does* regard as his rivals and predecessors. It will not be much, since they are scarcely known except from Aristoxenus himself, and his comments are almost invariably negative; but the attempt seems worth making, since so far as I can discover remarkably little has previously been written about those early musical theorists who cannot comfortably be sheltered under the 'Pythagorean' umbrella.

I shall begin by summarising the evidence on which I base my contention that

Aristoxenus found the work of the Pythagoreans in this field no more than irrelevant.

The central part of the Pythagorean programme seems to have been the analysis of the primary intervals of the scale in terms of mathematical ratios.³ Given this preoccupation it was natural for them to ask what these ratios are ratios of, and this question leads directly to the analysis of sound in terms of movement, and of variation in pitch in terms of variation in the ‘number’ of that movement, i.e. its speed.⁴ There were various theories as to the character of the variable velocity on which pitch depended. Two were of particular importance, the view adopted by Plato, probably by Archytas, and certainly by a number of writers in the Peripatetic tradition, that it was the velocity at which a sound is propagated; and the thesis ascribed to that rather shadowy figure known as Heraclides Ponticus, that it was the frequency of the vibration of the moving air.⁵ But Aristoxenus dismisses all such speculations out of hand. *μη παραττέωσαν δ’ ἡμᾶς αἱ τῶν εἰς κινήσεις ἀγόντων τοὺς φθόγγους δόξαι καὶ καθόλου τὴν φωνὴν κίνησιν εἶναι φασκόντων*, he says at 12.4-6. His point, emphasised several times on Meibom’s pages 9-11, is that such considerations have no bearing on the proper subject of harmonics, which is the character of musical sound as heard. The physical conditions of its production are of no harmonic interest.⁶

32.20 ff. is the one passage which deals plainly and directly with Pythagorean theory. Here Aristoxenus describes one class of his predecessors as *ἀλλοτριολογοῦντες καὶ τὴν μὲν αἴσθησιν ἐκκλίνοντες ὥς οὖσαν οὐκ ἀκριβῆ, νοητὰς δὲ κατασκευάζοντες αἰτίας καὶ φάσκοντες λόγους τέ τινας ἀριθμῶν εἶναι καὶ τάχῃ πρὸς ἀλλήλα ἐν οἷς τό τε ὀξύ καὶ τὸ βαρὺ γίνεταί*. All the marks of Pythagorean theory are here – the preference given to reason over perception, the analysis of pitch relations by means of numerical ratios, and the account of τὸ ὀξύ καὶ τὸ βαρὺ in terms of physical velocities. The authors of such speculations are simply stigmatised as *ἀλλοτριωτάτους λόγους λέγοντες καὶ ἐναντιωτάτους τοῖς φαινομένοις*; and apart from the remark in the following paragraph that harmonics is not geometry, and must make use of precise and accurately trained αἴσθησις, this school of thought is never referred to again. It is evident that Aristoxenus sees no need to pursue them on points of detail – their entire methodology rules them out from serious consideration in this context.

Thirdly, as an example of the way Aristoxenus in practice neglects Pythagorean researches, consider his repeated assertion (2.7-15, 35.1-13, and elsewhere) that none of οἱ ἔμπροσθεν studied any of the musical genera other than the enharmonic.⁷ The claim is puzzling in a number of ways, and I shall return to it, but for the moment the point is simple and clear. Unless our information in Ptolemy and Porphyry is altogether wrong – and though there are serious difficulties I don’t think that it is – all three of the genera had been studied and given complete, if controversial, mathematical analyses by Archytas.⁸ Even if we reject this evidence the difficulty remains, since there is no doubt at all that the scheme of ratios used by

Plato in the *Timaeus* yields a scale which is not enharmonic, but diatonic.⁹ Thus the fact that at least this other form of the scale had been given a quantitative analysis can scarcely have been unknown to Aristoxenus; but the analysis is Pythagorean, set in terms of λόγοι ἀριθμῶν, and is therefore irrelevant. Hence, though the question of the origin of a systematic distinction between the genera remains vexed and problematic – I shall say more about it below – these passages provide further evidence of a high order that Aristoxenus did not consider Pythagorean analyses as falling within the territory he was investigating.

One final point. There are in Aristoxenus' harmonics many items of substantive doctrine which are thoroughly incompatible with the Pythagorean approach. Two particularly obvious ones are his assertion and 'proof' that the interval of a fourth is $2\frac{1}{2}$ tones,¹⁰ and his assumption that no problem is presented by the division of the tone into two equal parts.¹¹ Yet he nowhere mentions that such claims are controversial, or even hints at it. Further, there was in the Pythagorean system one glaring and obvious flaw, that while the interval of an octave plus a fourth is clearly heard as a concord, in the system of Pythagorean ratios it has to be classified as a discord.¹² The interval in question appears in Aristoxenus' list of concords at 45.8–22, without any relevant comment; and one could hardly suppose that anyone with so waspish a tongue as he could have resisted the opportunity of mentioning, even in passing, so unambiguous an embarrassment to his opponents, had he considered them to be opponents at all.

As to the so-called ἁρμονικοί, my contention is that these are not to be regarded as some kind of super-empiricist extremists, but that the label is used by Aristoxenus to designate all those contemporaries and predecessors whom he takes to be working within his own field. The case is not easy to make out demonstratively, and I shall not claim to have presented proof: but the considerations which I shall mention seem to me to carry some weight.

First let me recapitulate and elaborate briefly the position which I want to contest. Porphyry, in his commentary on Ptolemy's *Harmonics*, quotes several authors, notably Didymus, and Ptolemais of Cyrene, to illustrate the principal differences between Aristoxeneans and Pythagoreans as these were currently understood.¹³ Broadly speaking there are two major distinctions. Whereas the Pythagoreans analyse pitch-relations, concords, and intervals generally in terms of λόγοι ἀριθμῶν, the Aristoxeneans treat pitches as points on an audible continuum of sound, separated by certain distances. This is a fascinating contrast, yielding important philosophical problems, but though I shall say a little more about it later, it is not my main focus here. Secondly, and for present purposes more crucially, they differ in their understanding of the roles of λόγος and αἴσθησις. Both begin from αἴσθησις: both recognise subsequently a role for λόγος, but for the Pythagoreans, once the starting point has been adopted, λόγος is the sole arbiter: if its results conflict with αἴσθησις, this merely proves the latter's inaccuracy and

unreliability. For the Aristoxeneans, ἀρμονική is concerned wholly with that which can be heard, and it studies the laws of music *as* heard. All judgments must therefore eventually be brought back to the test of αἴσθησις, and if reason purports to show, for example, that the interval of an octave plus a fourth is a discord when it is actually heard as a concord, then it must be reason and not perception which has gone astray.

Aside from these two main-stream approaches, Ptolemais also recognises (i) those who make ἀρμονική an entirely independent mathematical science with no place whatever for αἴσθησις,¹⁴ and (ii) those whose views begin from skill in practice, and who make little or no use of theory.¹⁵ Didymus further describes them as altogether ignoring λόγος, not in the sense that they make wholly irrational claims, but in that they give no demonstrations or arguments to support their assertions. Skill in practice forms the sole basis for the conclusions they reach, and he gives them the name ὀργανικοί or φωνασκικοί.¹⁶

Now it is perfectly true that a number of the criticisms which Aristoxenus levels at the ἀρμονικοί are to the effect that they are over-empirical, that they base their conclusions too much on the structure of actual instruments, that they present no αἰτίαι to support their conclusions, and so on. Hence, as I mentioned earlier, commentators have often supposed that he, like these later writers, is identifying a separate group with methods and presuppositions quite different from his own, and that the line-up of controversialists in his day would have had, perhaps, Aristoxenus versus Archytas in the centre, conceivably Plato out on the right wing, and the ἀρμονικοί on the far left. I have already argued that this picture of his relationship with the Pythagoreans is wrong: what I am now suggesting is that his criticisms of the ἀρμονικοί are not to be taken as identifying yet another separate stream of thought, but as criticising *all* the fumbling, relatively unscientific attempts of pioneers in his own field to establish the basic outlines of that science of which Aristoxenus sees himself as the Newton or Darwin.

The first time that Aristoxenus attaches the term ἀρμονικός to a group of persons he uses it to make a pun (2.8-11). Previous students of ἀρμονική, he says, were content ἀρμονικοὺς εἶναι μόνον, in the sense that of the three musical genera they studied only the *enharmonic* genus. (The noun usually used by Aristoxenus to refer to this genus is ἀρμονία, though he also often employs the adjective ἐναρμόνιος.) It would, I think, be very far-fetched to suppose that he intends the term to be recognised here as the title of a special school of thought: it is a catch-all for οἱ ἔμπροσθεν, and the pun is made possible by a combination of the common use of ἀρμονικός to refer to a student of harmonic theory with the special sense of ἀρμονία which designates the *enharmonic* genus.

In the paragraph which follows Aristoxenus attributes several shortcomings to these predecessors. One is their failure to consider any but the *enharmonic* genus. Secondly, he attributes to them the use of certain διαγράμματα, in whose use they fail adequately to represent τὴν πᾶσαν τῆς μελωδίας τάξιν (2.11-17). They dealt

only with the arrangement of the octave, and not of the other *μεγέθη* and *σχήματα* (2.17-25). No one, he says, has dealt with these other matters, and what they have discussed they have treated imperfectly – as he himself has shown previously *ὅτε ἐπεσκοποῦμεν τὰς τῶν ἁρμονικῶν δόξας* (2.25-30).

It is a great pity that the work he here refers to is lost. But at least it seems clear that he is making no distinction as yet between *οἱ ἁρμονικοί* and *οἱ ἔμπροσθεν* generally.

Passages from elsewhere in the work confirm this first impression. The failure of his predecessors to consider any but the enharmonic genus is referred to again at 35.1-13: here the word *ἁρμονικός* does not occur: we are simply told that no one (*οὐδεὶς*) has worked on the other genera. We seem to meet the ‘diagrams’ mentioned in section 2 in at least three other passages, all associated with the term *καταπύκνωσις*. The reference is apparently to the representation of scales on a map or diagram consisting of a line divided at intervals of an enharmonic diesis, or quarter-tone, and I shall go into its significance in some detail later. One passage (53.3-11) mentions it in connection with the concept of continuity, *τὸ ἐξῆς*, and uses the phrase *οἱ εἰς τὴν καταπύκνωσιν βλέποντες*: this makes it likely that not all Aristoxenus’ predecessors employed it. In an earlier section (27.34-28.3) also concerning continuity, we are told *ζητητέον δὲ τὸ συνεχὲς οὐχ ὥς οἱ ἁρμονικοὶ ἐν ταῖς τῶν διαγραμμάτων καταπυκνώσεσιν ἀποδιδόναι πειρώνται*. Here it is plain that Aristoxenus is willing to associate the term *καταπύκνωσις* and the use of the relevant diagrams with people labelled as *οἱ ἁρμονικοί*. In yet another passage (7.22-5), speaking of modulation and the proper relation of *συστήματα* to *τόποι*,¹⁷ he says that we should discuss them *οὐ πρὸς τὴν καταπύκνωσιν βλέποντας καθάπερ οἱ ἁρμονικοί*: and again (7.30-2) that some of *οἱ ἁρμονικοί* have touched on the matter *κατὰ τύχην*, not with this issue in mind but *καταπυκνῶσαι βουλομένοις τὸ διάγραμμα*. Again we seem to have a clear association of *οἱ ἁρμονικοί* with *καταπύκνωσις*, and this might easily be taken to indicate a reference to some special school: yet the very same sentence continues *καθόλου δὲ οὐδενὶ σχεδὸν ἐν τοῖς ἔμπροσθεν φάνερον γεγένηται τοῦθ’ ἡμῖν*, which while not actually entailing that the reference of the term *ἁρμονικοί* is in fact quite general, certainly suggests it. We are at any rate not justified in following Macran’s prejudicial translation and rendering *οὐδενὶ* as ‘no single writer belonging to this school’.¹⁸

If the associations of the terms *ἁρμονικός* and *καταπύκνωσις* were taken on their own, my case would be at best flimsy. The evidence, if anything, would go the other way; and these passages more than balance out the argument which I based on his references to his predecessors’ obsession with the enharmonic genus. It is a different story, however, when we come to his criticisms of them for failing to deal properly with *σχήματα* and *μεγέθη* other than the octave. We have seen that these failures were described in his work concerning *τὰς τῶν ἁρμονικῶν δόξας*. On Meibom’s pages 5-6 this criticism is elaborated, with reference explicitly to the work of one Eratocles, who is not known from any other source. I shall return to him later, but

the nub of the critique is first that Eratocles fails even to enumerate all the *φαινόμενα* correctly, and secondly that he does not adduce *αἰτίαι* for his conclusions. It is therefore interesting that in the passage where he deals most generally with all other theorists, he divides οἱ ἔμπροσθεν simply into two groups: there are the Pythagoreans, who are irrelevant, and there are all the others, who make their claims *ἄνευ αἰτίας καὶ ἀποδείξεως*, and who do not even make an adequate enumeration of *αὐτὰ τὰ φαινόμενα* (32.20-31). It can hardly be doubted that Eratocles is here being taken as representative of οἱ ἔμπροσθεν generally, and since the faults in question are precisely those which were earlier attributed to οἱ ἁρμονικοί, there is a strong presumption (i) that Eratocles is an ἁρμονικός, and (ii) that in this context at least the expressions οἱ ἔμπροσθεν and οἱ ἁρμονικοί are terms with the same reference.

I should like to mention briefly two other passages. At 37.8-35 he seems to use as proof of his assertion that no one (οὐδεὶς) has said anything significant about *τόνοι* the fact that the treatment of this subject by οἱ ἁρμονικοί is entirely random; and he mentions three conflicting groups of claims made about *τόνοι* by different ἁρμονικοί. This at least shows that the ἁρμονικοί are not a monolithic school, and seems also to indicate that a bundle of information about οἱ ἁρμονικοί is tantamount to information about all his predecessors.

Secondly, in 39-40 he criticises at length the thesis that the aim of his science is an accurate notation. This thesis, which I shall discuss further below, is simply attributed to *τινές*: and it is not until after the long passage is complete that οἱ ἁρμονικοί are named, in a rather ambiguous expression embedded in the clause *εἰ μὲν οὖν δι' ἄγνοιαν τὴν ὑπόληψιν ταύτην ἐσχέκασιν οἱ καλούμενοι ἁρμονικοί ...* (40.25-6). Now this expression might easily be read as 'the so-called ἁρμονικοί', and taken to name this supposed special school. But if that is right, why did Aristoxenus not make the attribution at the beginning of the argument? He has done nothing to show that the people he is talking about belong to some special school – they are so far merely *τινές*. The point, I think, is contemptuous, for Aristoxenus is here in a particularly scathing mood. 'These so-called ἁρμονικοί' means 'these people who dignify themselves with the honourable title of students of ἁρμονική, but in fact do not deserve it'.

One general point will complete this survey of the evidence in the text of Aristoxenus. If the notion that οἱ ἁρμονικοί constituted a special school were correct, one would expect to find special criticisms also attached to other specific groups. Nothing of the kind is to be found, apart from one off-hand and incomprehensible reference to the much older musician Lasos of Hermione (3.20-4). At least one would expect to meet criticism of kinds of approach, method, or doctrine which are not those associated explicitly with οἱ ἁρμονικοί; but this is not so either. As far as I can judge, though there is one focus of criticism, the use of *καταπύκνωσις*, which is virtually always linked with the term ἁρμονικός, there is no significant focus of criticism which is never associated with it. I conclude that –

Pythagoreans apart – there is no school of musical thought known to Aristoxenus for whose members the label ἁρμονικοί would have seemed inappropriate.

I might add two small pieces of indirect evidence. The word ἁρμονικοί, used in reference to students of ἁρμονική, occurs in Theophrastus Fr. 89, where it distinguishes those who make important use of αἰσθήσις from the μαθηματικοί, presumably Pythagorean, who do not; and though Theophrastus concedes that some people might consider these ἁρμονικοί unscientific, his objective is in fact to discredit the μαθηματικοί. For present purposes the important point is that he mentions no possible third group. There are the ἁρμονικοί and there are the Pythagoreans, and that is all.¹⁹

A similar point might be extracted from the famous passage at *Republic* 531a-c. Though Plato does not use the word ἁρμονικός, there seems a pretty direct relation between his χρηστοί, desperately listening for minute differences in pitch, and Aristoxenus' ἁρμονικοί: there is even the verbal link between Aristoxenus' καταπύκνωσις and Plato's descriptive phrase πυκνώματ' ἅττα ὀνομάζοντες. I shall return to this passage later: for the present my point is that once again – Plato's own doctrine apart – only the two 'schools' are mentioned, these 'empiricists' and the Pythagoreans.

I shall now move on to the remaining part of my programme, to see what can be said about the methods and aims of these predecessors of Aristoxenus. I shall mention a number of issues, but I shall focus most sharply on the procedure – if that is what it is – known as καταπύκνωσις. I take this as central to my picture partly because Aristoxenus obviously considers it important, and partly because it gives us at least a toe-hold in something positive. It is hard to build up much of a picture on the basis of a list of things which the ἁρμονικοί did *not* do.

At its most straightforward, what καταπύκνωσις seems to involve is the construction of a diagram in the form of a line, with a series of marks at equal intervals along it. These marks represent the boundaries of the smallest musical intervals: the diagram, in fact, represents a series of quarter-tones. On to this line scales could then be mapped in a way which revealed the sizes of the component intervals.²⁰

If Aristoxenus is to be believed, the purpose of this construction is to be connected with the following matters:

(i) The explanation of the natures of musical σχήματα and μεγέθη: that is, the analysis of the interval-structures of the various scales, the smaller components of which they are constructed, and the complex arrangements which can be formed by their conjunction (2.15-25).

(ii) The relations between τόνοι ('modes'); μίξις or 'modulation'; and the appropriateness of particular kinds of scale to particular τόποι, or ranges of pitch. Aristoxenus seems to say that the καταπύκνωσις diagrams *could* have been used to deal with these matters, but that the ἁρμονικοί ignored them or treated them only κατὰ τύχην, in passing: this suggests that for the ἁρμονικοί their real value lay elsewhere (7.4-34).

(iii) The nature of τὸ ἐξῆς, musical continuity. Of this Aristoxenus complains that the ἀρμονικοὶ thought of their quarter-tone series as *representing* τὸ ἐξῆς; whereas, he argues, no more than two quarter-tones can ever occur successively in a proper musical sequence, and hence the principles determining which note can properly follow another must lie elsewhere (27.34-28.17, and 53.3-15).²¹ I shall have a little more to say about this later.

We may note further, in a preliminary way, that the use of καταπύκνωσις seems to have had rather general associations with (a) the restriction of research to the structure of the enharmonic octave, and incompleteness and inaccuracy generally (2.7-25: cf. 6.13-19, 32.29-33.1, 37.35-38.5), (b) an excessive empiricism, which excluded the formulation of αἰτίαι, explanations for the conclusions reached (6.13-14, 32.29-30), and (c) an emphasis on correct quantitative notation as an important aim of the science (39-41).

One might well wonder why Aristoxenus should have regarded the procedure I have described as more than harmlessly illustrative. There are, I think, quite sensible answers to this question; but more pressing in the present context is the question why it should have been of any serious interest or importance to its own authors. It seems a simple matter to draw a diagram of this kind and to mark the positions of notes on it; and it seems strange to suppose that the construction of something so apparently trivial should have been a central part of anyone's programme for harmonic science. But I think that it can be shown that such appearances are deceptive, and that the development of the καταπύκνωσις diagrams must have been both significant and difficult.

Consider the circumstances. Before the fourth-century theorists began to work on them, the scale-forms employed by Greek musicians in actual music seem to have been multifarious and chaotic. As far as scholars have been able to judge, different kinds of music may well have employed differently organised series of notes, but no one had sought or discovered any determinate principles by which they could be related and compared to one another. The characters of the different kinds may have been more or less recognisable, but there had been no systematic attack on the question what it was that generated these different characters. It is not even clear that these differences were primarily identified as differences in interval-structure rather than e.g. relative height and depth of pitch. It was during the fourth century that these distinctions were first pinned down to differences in interval-structure, and these differences compared, organised, and eventually fossilised, and it is in the context of the project of developing these comparisons that καταπύκνωσις is, I believe, to be understood.²²

The investigators who began this work were hampered by the lack of any appropriate tools. There was of course no key-board, on which the relative sizes of intervals might immediately be revealed. Nor was there any notational system which represented the relative sizes of intervals as the modern stave does. Such notation as is known identifies φθόγγοι not by pitch, but by δύναμις, that is, by the

functional role performed by that note in the scale.²³ Aristoxenus himself argues for the view that the notes in the scale are to be considered as δυνάμεις, restricted more or less narrowly to a particular τάσις or pitch by the nature of the relevant μέλος, and against the thesis which he ascribes to his predecessors that φθόγγοι are to be simply identified as τάσεις (see two extended passages, 39–41 and 46–50). It is easy to infer from what he says that this notion of δυνάμεις is a new one, and that the view against which he is arguing is that of the ordinary practical musician,²⁴ but I think that such an inference would be mistaken. The existing notational system was, so far as we can tell, already based on δυνάμεις. On this principle the next note above a given note in the scale is not necessarily a quarter-tone higher, but is the next natural note *of* that scale. The idea that there may be notes, and a definite number of them, between two notes of an accepted scale is already quite sophisticated, and depends on the possibility of thinking of the interval-series quantitatively, independently of given scale structures. And the possibility of thinking in this way is plainly a precondition of the quantitative comparison of the interval structures of the *different* accepted scales. I suggest, then, that this idea is not one which arises directly out of common musical practice, but one developed by Aristoxenus' predecessors as a tool of analysis. It is previous theorists and not practical musicians who are under attack in the passages cited above.

Once we have the idea that intervals in a scale can be quantitatively compared, and that it is not the case that the next note up a given scale is the same distance above its predecessor as the next one down is below it, the question which must be tackled is how the relative sizes of the steps of the scale can properly be determined. It is here that the relevance of the κατατύκνωσις diagram can first be seen. It is an abstract schema on to which any scale, indeed any collection of different scales, can be plotted, and by means of which the sizes of their intervals can be compared: and it provides for the first time the possibility of a quantitative notation, allowing us to write down unambiguously any heard sequence of pitches. Aristoxenus, as we have seen, treats the view that an accurate quantitative notation is the crucial aim of harmonics with contempt; but if my argument is near the truth his disdain is scarcely justified.

We can thus at least guess at one major objective of those who employed the κατατύκνωσις diagram. We should also notice that it must have been extremely difficult, in the first instance at any rate, to establish and to use. The first and most important requirement is to identify a usable unit of measurement. The notion of a tone, for instance, and the possibility of picking out a given heard interval as a tone, is not simply given in experience. The most which the earlier ἁρμονικοί are likely to have had at their disposal as preestablished truths is that there are three principal audible concords, and that the combination of the smaller two of these produces the third.²⁵ and plainly this fact by itself gives no basis for measuring and comparing small intervals.

Though Aristoxenus objects to the practice on quite sensible grounds (55.3–11,

cf. 52.35-53.34), it is natural to start from the idea that the unit of measurement should be the smallest interval which the ear can distinguish. This would have the advantage that we should not then need to talk in terms of fractions of it, whose measurement would be likely to cause problems. That this was established practice by the middle of the century is clear from the evidence of Aristotle, who states as an uncontroversial fact that the μέτρον in music is the δίεσις, and compares it with other supposedly indivisible units of measurement.²⁶ It is interesting that he does so, in view of his general adoption of a Pythagorean approach to musical structures, based on ratios: since if we take the Pythagorean view there is no place for the notion of a μέτρον, and the division of the octave into small equal intervals becomes impossible. Pythagorean theory is in fact quite incompatible (in the absence of the modern logarithmic system of 'cents') with the analysis of musical space in terms of a line equally divided to represent equal intervals. This point is not especially recondite, and Aristotle, if challenged, would no doubt have agreed: the fact that he nevertheless refers without comment to the δίεσις as the musical μέτρον suggests that it and the procedures associated with its use were elements of a common and familiar approach, and not by then new or controversial.²⁷

How is this μέτρον, the smallest musical interval, to be identified, and how is it to be compared with other intervals so as to function as a unit of measurement? *Republic* 531 gives us a caricature vignette of the worthy professors enthusiastically and argumentatively trying to determine by ear whether *this* is the smallest detectable interval, and whether this other is smaller, or has reached a genuine unison. Plato represents them as wasting their time in trivial nonsense, and so from his special point of view they were. But he does make quite clear what it was that they were aiming at – the establishment of a musical μέτρον, or as Glaucon puts it, the μικρότατον διάστημα, ὃ μετρητέον (531a7). Their method is purely empirical, open to accusations of subjectivity and inaccuracy: but it is difficult to imagine what other kind of procedure they could have employed.

It appears that in time the μέτρον came to be identified with what Aristoxenus calls the least μελωδούμενον, the enharmonic diesis. This is not understood as an artificially constructed interval: it is one which actually appears in certain forms of the scale, being that which occurs twice in the πυκνόν of an enharmonic tetrachord.²⁸ Nevertheless, we can hardly be sure that the enharmonic diesis or quarter-tone of analysis represents *exactly* what musicians of the period would have played in this part of the scale, or even that the two lower intervals of the enharmonic πυκνόν as played in practice would always have been exactly equal.²⁹ The notion of 'equal intervals' bounded by different pitches is itself already a step away from practice, and it is one whose operational identification, given the resources of the time, must have been problematic, to say the least.

Thus the ἁρμονικοί, in making this first step, were doubtless beginning also the process of standardisation and artificial rigidifying which over the next half-century seems gradually to have been reflected back from the theorists to the music of practice. We shall meet other signs of it later.

But now let us suppose that this interval, as it occurs in the enharmonic scale, is standardised and identifiable. There was no one to tell the ἄρμονικοί that the interval in question is a quarter of an Aristoxenean tone – a quarter, that is, of the difference between the two smallest concords – nor that the smallest concord of all, the fourth, contains $2\frac{1}{2}$ Aristoxenean tones. If they began, as our evidence suggests, from the analysis of the so-called enharmonic octave, it was no small achievement for the ἄρμονικοί to have determined by ear alone and without recourse to theoretical αἰτίαι how many such dieses there are in the residue of the fourth after the first two intervals (there are eight), and how many in the complete octave (there are twenty-four). Given that Aristoxenus is lavish elsewhere in his accusations of inaccuracy, the fact that he never levels them at this feature of their analysis must be construed as something of a tacit tribute.

Suppose then that the μέτρον has been established, and that the number of times it fits into each of the principal concords – the fourth, the fifth, and the octave – has been determined. The next, and in this context the final step, will be to map the interval structure of the existing and accepted scales of Greek music on to the καταπύκνωσις diagram. Here Aristoxenus does offer accusations of inaccuracy (2.25-3.4, 6.13-19, 32.30-1), and this is hardly surprising. In the first place, even given a rigid standardisation of existing scales, their mapping would have been difficult, requiring a most sensitive and highly trained ear (cf. 19.23-9, 33.22-6). Secondly and more importantly, there is no evidence and no real probability that the tuning of scales before Aristoxenus was sufficiently standardised for any pitching on a series of quarter-tones to be universally acceptable. There had been no means by which such rigid uniformity could have been established and imposed, even if it were felt desirable. In a sense Aristoxenus is quite right in his criticism, and right too in associating it with the failure of the ἄρμονικοί to base their analysis on theoretical αἰτίαι: for any mapping of scales which cannot point to principles which explain why the scales should be as they are is open to the suggestion that in fact they are *not* like that.

It is also worth raising at this point the question why Aristoxenus could claim that the ἄρμονικοί gave analyses for scales of no genus other than the enharmonic. There were, on his and later accounts, two other genera, the chromatic and the diatonic, each with its minor variants or χροαί: and there is no doubt that the diatonic forms at least are very old.³⁰ So why did the ἄρμονικοί ignore them?

The question is in fact very difficult to answer, or even to get to grips with. Central to the difficulty is the fact that until Aristoxenus (at least if we ignore for now the late evidence about Pythagorean authors) no writer even suggests the possibility of analysing Greek musical forms into species of the octave, later known as ‘modes’, each of which can occur in all of three variants, corresponding to the scheme of intervals of each of the three genera. The adjectival names which Aristoxenus attached to the genera are indeed used by the author of a papyrus fragment, commonly supposed – though in my opinion on inadequate grounds³¹ –

to be pre-Aristoxenean; but they are not attached there to the noun γένος (their nouns are μέλος and μουσική); the author's use of them appears to be confused, or at least imprecise;³² and it is wholly unclear what kinds of distinction they are intended to mark. We have in fact very little evidence at all of the nature of harmonic structures, real or supposed, which the music of the relevant period displayed; and what we do have indicates that modal and generic forms were by no means settled and clear. The various ἀρμονίαι mentioned by Plato, for instance, seem to be distinguished from one another by no such rigid and regular patterns.³³ Broadly speaking, the main kinds of distinction – difference of order of intervals, of sizes of variable intervals within a basic order, and of high and low pitch – appear to have been unanalysed and simply thrown in together as difference of 'character'.³⁴

There has been a good deal of controversy from time to time about the authenticity of the 'ancient scales' set out by Aristides Quintilianus, and purporting to be those indicated by Plato in the *Republic*.³⁵ I am not going to enter this controversy now. But if they, or anything roughly like them, do represent scale-forms current in the later fifth and early fourth centuries, two important observations can be made. One is that while there is no way of fitting these scales without some adaptation into the standardised Aristoxenean scheme of 'modes', one can see how such modification could without too much violence be achieved. Some of them fit more or less directly, others with only minor tinkering, and others again with a little addition or filling out.³⁶ Secondly, the outstanding common feature of all but one of them is their possession of the interval sequence quarter-tone, quarter-tone, ditone, which is the primary signature of the enharmonic genus as later systematised. From the first of these observations it is possible to speculate about the nature of the process of 'rationalisation' by which Aristoxenus arrived at his tidy organisation of the modes. I shall mention this again briefly in a moment, but it is not at present the central point. The second observation suggests that anyone looking for neat recurrent patterns in the musical forms of the period would inevitably be struck by the repeated occurrence of a tetrachord of the form quarter-tone, quarter-tone, ditone, and thus that an analysis which came out looking much like Aristoxenus' enharmonic genus is to be expected. Further, we have a well attested tradition that the enharmonic was the genus of the music of tragedy.³⁷ If it is true that this music was by convention based around a tetrachord of the relevant form, there would have been a convenient and unified source from which such scales as Aristides presents could have been collected.

Nevertheless, Aristoxenus must have found a basis for his diatonic and chromatic genera somewhere, and we have seen that there is good evidence for the early existence of the scale-forms they include. Why, if Aristoxenus is right, were they given no analysis by his predecessors?

The question is one to which I have no adequate answer, but a couple of points may have some relevance. When Aristoxenus himself gives his analysis of the intervals corresponding to the different genera, it is only the enharmonic which

appears in a single, unique form. The others, as I noted earlier, are variable as between different 'shades', *χρόαι*, or minor alterations in tuning. Now of these variants Aristoxenus makes the following assertions. (i) The different *χρόαι* exist, and can be given a quantitative analysis (see especially 21.20-7, 50.19-52.33). (ii) No one has previously produced such analyses (35.1-25). (iii) The points at which one genus or shade passes into the next are obscure not only to theoreticians, but also to the practitioners of music themselves (23.1-33, 35.9-25).³⁸

What these points add up to, I think, is that the practice of musicians in tuning for those forms which Aristoxenus analyses as diatonic and chromatic was very variable, and involved no definitely fixed distinctions corresponding to his system of genera. The various so-called *χρόαι* are not originally understood as distinct entities, but as subtly different-feeling versions of the same thing, dependent perhaps on personal or social taste. Aristoxenus' claim that musicians of his day tend to 'sweeten' (*γλυκαίνειν*) the genera which incorporate the smallest intervals by raising their upper bounding notes seems to indicate something of the sort (23.13-23). Some such variants were perhaps employed in pursuit of particular musical effects: modern performers, especially in small choirs or instrumental consorts, are familiar with instructions such as 'tune that note high', used for harmonic and contextual reasons or for affective purposes. At any rate, it appears most improbable that there existed an orderly collection of diatonic and chromatic forms simply awaiting Aristoxenus' analysis: in quantifying the higher genera he is less analysing an existing order than inventing a new and rigid scheme which could plausibly be imposed on what had in practice been quite fluid. His methods, which as I have argued elsewhere are open to serious objections,³⁹ involve the derivation of 'truths' about these scales from certain primary principles (*αἰτίαι*) on the basis of which he is able to insist that this or that *must* be correct. But there can be no wonder if his predecessors, with their neglect of *αἰτίαι* and with methods which were wholly empirical, had failed to pinpoint the positions of the movable notes in these genera, for they were not so definite as to be pinpointed by such methods on a gradient as sensitive as the quarter-tone series. Further, there can be no question of working out the pattern of e.g. the 'hemiolic' *χρόα* of the chromatic genus until analysis and theoretical structuring have progressed to a point where the *existence* of such a thing is recognised.

In Aristoxenus' scheme, the enharmonic genus is the only one which does not admit of variations of *χρόα*. This should not, I think, be taken to mean that there was before his day something unambiguously fixed and unanimously accepted as the form of the enharmonic genus: it means rather that there existed a relatively clear-cut and fairly comprehensive group of scale-forms which as a matter of fact shared the main features characteristic of his 'enharmonic'. As we have seen, the 'ancient scales' of Aristides Quintilianus do just that; and we have seen that they can also, with some manipulation, be presented so as to appear as cyclically organised 'modes' within the enharmonic scheme. It is clear from Aristoxenus' evidence that

the possibility of this cyclic ordering was recognised by Eratocles (6.19-31).

From the point of view of those involved in the first attempts at this kind of analysis, a group of scales like those of Aristides has obvious advantages. First, its members actually employ the enharmonic diesis, whose use as a μέτρον is thus made easier. Secondly, it can be presented as a set whose members share important features, and are capable of being related to one another in an orderly and systematic way. If, as seems likely, those existing scales which were not members of this group presented no such recurrent features and no such neat interrelations, it is perhaps less surprising that the ἁρμονικοί left them alone. There is a well attested tradition, even in Aristoxenus, for the sentiment that the enharmonic, despite its lack of historical priority, was the purest and most 'classical' genus.⁴⁰ The fact that there was an identifiable collection of scales actually employed in cultivated musical practice which, unlike others, was capable of being ordered in this way may well have contributed to this feeling. And I would suggest that the Aristoxenean invention of systematic groupings of other scales in the different 'modes' of the various χροαί and γένη is likely to have been based in the first instance on the analogy of what could be done with the 'enharmonic' group. If this sort of diagnosis is correct, it is misleading of Aristoxenus to accuse his predecessors of failure to analyse the other genera: the notion of a genus is itself his own way of extrapolating from the order identified by Eratocles and the other ἁρμονικοί in one selection of scales, so as to capture in similar schemata the residuum which had not hitherto been brought into any kind of order at all.⁴¹ How much violence to the actually existing forms this extrapolation entailed we do not know: it undoubtedly involved the invention of a great many new scale forms to fill gaps in the classification which he proposed, and which subsequently became canonical. But if the methods of the ἁρμονικοί involved, as they seem to have done, the identification of regularly repeated components in scales, and if in the absence of any rational αἰτίαι they were confined to wholly empirical procedures, there was no sensible way in which they could have pursued their researches in relation to scale-forms which were variable, and lacking in the regular repetitions of form which characterise the 'enharmonic' group of Aristides.

If the picture I have been painting seems at all plausible, several of Aristoxenus' other criticisms may also be misplaced.

(i) While admitting the attractions of his primary thesis that melodic sound has laws of its own, it is far from clear that he is right. If the facts of musical practice are fluid, especially in the absence of keyboards, and before musicians themselves begin to be influenced by the quantitative analyses of theorists, there may be fairly general truths about taste, but scarcely laws. Hence the demand for αἰτίαι to explain from first principles why scales have the structures which they do have may be inappropriate. In any case, before any αἰτίαι can properly be established, the facts of musical practice must be set out in such a way as to be susceptible of accurate abstract representation and analysis; and this is the function of the painstaking,

strictly and ‘merely’ empirical development of the *καταπύκνωσις* diagrams.

(ii) Aristoxenus seems to suggest that his predecessors tried to represent several different forms of the scale in the same diagram, and he takes them to task for misrepresenting the pitch-relations between these different *τόνοι*, that is, those different orderings of the same series of intervals which came to be called modes (7.22-8.2). Aristoxenus’ objective in this context is to say something about modulation, the ways in which a *μέλος* may properly shift from one such mode to another, and at which relative pitches: and certainly the practice of packing these various modes closely together on the quarter-tone series would not have served that purpose.⁴² But if my earlier remarks were correct, this was not the main aim of the *ἁρμονικοί*: they were not, or not primarily, attempting to work out the possibilities of melodic modulation, but on the contrary to *abstract* from the different ranges of pitch at which the various *τόνοι* might actually have been played, in order to display most readily the differences in the sizes and arrangements of their intervals. Plainly this can best be done if they are represented, so far as is possible, at the *same* pitch, i.e. the same stretch of the diagram. Their ‘ignoring’ the proper relations between *τόνοι*, or representing them correctly only *κατὰ τύχην*, will then have been the result not of incompetence or ignorance, but of a deliberate and perhaps difficult abstraction of difference in interval structure from difference in pitch.

Similar things could be said about the complaint that those who use *καταπύκνωσις* ignore *ἢ τοῦ μέλους ἀγωγή*. Of course the quarter-tone diagram does not represent, or would not represent to any Greek, a note series which could form the basis for any recognisable *μέλος*. But it does serve the quite different purpose of forming a quantitative structure on to which legitimate melodic sequences can properly and usefully be plotted: the quantitative analysis of the features of acceptable *μέλος* could hardly begin without it.

(iii) More obscure is Aristoxenus’ complaint that the *ἁρμονικοί* dealt only with the form of the octave, and not with that of other *μεγέθη* such as the fourth and the fifth (2.17-30). In one sense analysis of the octave must involve analysis of these others, since they are its parts. But perhaps what Aristoxenus means is that whereas they displayed the various possible forms of the octave, they did not explain, for each arrangement of the interior of a fourth or a fifth, where it could fit in to the structure of the octave, and how it could be conjoined with other forms. For instance, there are four possible ‘enharmonic’ arrangements of the fifth, and three of the fourth. Which can follow which, and why? Why are no other arrangements possible? If these are Aristoxenus’ questions, they are fair ones, but with an important qualification. He tells us (6.11 ff.) that Eratocles, in his enumeration of the forms of the octave, made use of the fact that these forms make up a cyclically recurring sequence. His enumerations and diagrams must therefore have displayed, at least potentially, all the non-modulating sequences and arrangements of fourths and fifths within the enharmonic genus. What he did not present was any

explanation, any αἰτίαι, which would count as reasons why these sequences and arrangements must be as they are.

To put it another and perhaps more sensible way, if Eratocles had no notion of the identity of something called the ‘enharmonic’ genus and the principles which governed it, but was merely putting together a number of scale forms which he had found, as a matter of fact, to be in practical use, there was no way in which he could have shown why the fourths and fifths of his scales are subdivided as they are, nor that they could not be divided otherwise; nor could he say what other forms were possible. Then, as Aristoxenus says, his empirical procedure cannot guarantee that the basic forms of the fourth and the fifth *must* be as they are. The principle of cyclic recurrence will yield potentially not Eratocles’ seven forms of the octave, but πολλαπλάσια τῶν ἑπτὰ (6.29–30): for in the absence of principles to tell us what the legitimate divisions of the fourth and the fifth are, we might posit *any* such divisions and make them cyclically recur.

To end this paper let me give a brief résumé of the position for which I have been arguing. I have suggested that Aristoxenus’ criticism of the ἁρμονικοί on the grounds that they fail to analyse genera other than the enharmonic is simultaneously unsurprising and misleading. The notion of a ‘genus’ itself presupposes a theoretical structure which the ἁρμονικοί lacked; and it may have been precisely their work on a collection of scale-forms close, perhaps, to Aristides’ ancient scales, and ordered into a cyclic scheme by Eratocles, which provided the starting point for Aristoxenus’ more ambitious modal and generic system. Their lack of theoretical presuppositions made it impossible for them to extrapolate, as Aristoxenus could, from cases where order already existed to those, later grouped into the other genera, where order was lacking in practice, and had to be imposed.

Similarly, they can be credited with no treatment of the principles of modulation (which would already presuppose something like a system of modes), or of the ordering of σχήματα within the octave, precisely because the whole notion of autonomous principles of music is born with Aristoxenus. His predecessors were concerned to analyse and quantify what they found, and developed for this purpose the powerful, if awkward, instrument of the καταπύκνωσις diagram, which they used to give a framework within which the structures of the different scales could be quantitatively compared, and on which the sizes of intervals within each scale could be measured. By this means they were led to the discovery that one established group of scales shared a common feature, the pattern quarter-tone, quarter-tone, ditone within a tetrachord, and that the members of this group could be represented as cyclically recurring. This gave them one orderly set of scale forms over against a disordered confusion of others, and may have led to the feeling that there is something rigorous, pure, and ‘classical’ about what came to be called the enharmonic genus.

Their empirical findings constituted essential data for the later system-builders. Equally, the Eratoclean cyclic arrangement provided the foundation for the entire

Aristoxenean canon of modes and genera. This canon, like the theories of the Pythagoreans whose divorce from αἰσθησις Aristoxenus mentions in passing, and his disciples enthusiastically attack, is highly artificial, and it decisively turned the face of musical theory away from actual practice: but at least the ἁρμονικοί, in their innocence of considerations of theory and principle, cannot justly be held to blame for that.

UNIVERSITY OF WARWICK

ANDREW BARKER

NOTES

1. See e.g. H.S. Macran, *The harmonics of Aristoxenus* (Oxford 1902) 87-8, 226, E.A. Lippman, *Musical theory in ancient Greece* (New York 1975) 145. I have myself rashly assumed this position in the past, explicitly in 'Music and Mathematics', *PCPS* n.s.23 (1977) 14 n. 8. The present paper is in part a recantation of the view adopted in that note: the thesis I am now suggesting is stated but not argued in S. Michaelides, *The music of ancient Greece: an encyclopaedia* (London, 1978) s.v. Harmonikos.

2. Theophrastus fr. 89 (Wimmer). I have discussed a relevant part of it in the article cited in n. 1, but the beginning of the fragment, not dealt with there, is also to the point.

3. Cf. Diels/Kranz *Die Fragmente der Vorsokratiker* (1952 and later editions) 47, A16, A17, A19, B2 (Archytas), 44, A25, A26, B6 (Philolaus), Plato, *Timaeus* 35b-36b. The procedures are fully exemplified in the Euclidean *Sectio Canonis*.

4. See e.g. D.K. 47, B1 (Archytas), Plato, *Tim.* 67b, Aristotle, *Top.* A, 107a11ff., Aristoxenus, *El.Harm.* 32.19-28, and the comments of K. von Jan, *Musici scriptores Graeci* (Leipzig, 1895) I. 134-41, W. Burkert, *Love and science in ancient Pythagoreanism* (tr. E.L. Minar Jr., Harvard, 1972) ch.5, section 1.

5. Porphyry's *Commentary on Ptolemy's Harmonics*, 29.27-31.21 (Düring). Questions about the connection between a sound's pitch and some physical velocity were also much discussed in the Peripatetic school: cf. Ar. *de Anima* 420a27-b5, *de Gen.An.* 786b12ff., *Hist.An.* 545a14ff., 581a17ff., ps.-Ar. *Problems* XI, 3, 6, 10, 11, 13-16, 19-21, 32, 34, 40, 47, 50, 52, 53, 56, 61, 62.

6. I discuss this matter in an article 'Music and Perception', *JHS* 98 (1978) 9-16.

7. In the scales discussed by Aristoxenus certain notes are 'fixed': that is, they stand at set intervals from one another. Between them lie notes which are moveable, and with certain systematic variations in the intervals between them and the fixed notes we get what Aristoxenus calls change of γένος. There are three genera, enharmonic, chromatic, and diatonic. The enharmonic, which is referred to here, is characterised primarily by two very small intervals (quarter-tones) in the lower part of each tetrachord, followed by a jump of a ditone to the next fixed note, a fourth above the original pitch. For the details of his analysis of the interval structures of the genera, see 22-7 and 46-52.

8. D.K. 47 A16 (from Ptolemy), A17 (from Porphyry). See also the passages cited in n.3 on Philolaus.

9. *Tim.* 35b-36b. See the discussion of the *Timaeus* scale with reference to the supposed fragments of Philolaus in Burkert op.cit., ch.5, section 2.

10. *El.Harm.* 56.13ff. Contrast Eucl. *Sect. Can.* 15.

11. *El.Harm.* 50.15ff. and *passim*. Contrast *Eucl. Sect. Can.* 16 (the argument depends on the proof given in 3).
12. Explained in *Ptol. Harm.* 11.18-12.7 (Düring). The classification of ratios from which the problem arises can be found in *Eucl. Sect. Can.* 1.
13. Porphyry *op. cit.* 23.24-31, 25.3-28.27.
14. *Ibid.* 25.10-14.
15. *Ibid.* 25.14-16.
16. *Ibid.* 26.6-15.
17. A σύστημα is a scale, in the sense of a particular order of intervals. A τόπος is a range of pitch. Aristoxenus is concerned, in the passage cited, with the question whether the different συστήματα are to be arranged at any particular pitches relatively to one another. See *Macran op. cit.* 229-32, 262-6.
18. *Macran op. cit.* 170.
19. Theophrastus *ap. Porphyry op. cit.* 61.24-62.3.
20. The procedure is never fully described by Aristoxenus, but can be fairly confidently reconstructed in the way I have indicated on the basis of his scattered remarks about its uses and misuses. See the passages referred to in the Index Verborum of the edition of R. da Rios (Rome, 1954) s.vv. καταπύκνωσις and διάγραμμα.
21. *Macran op. cit.* 251-2, and see my paper cited in n.6 above.
22. See e.g. R.P. Winnington-Ingram, *Mode in ancient Greek music* (Cambridge, 1936), especially 81 ff.
23. The subject of Greek notation is a delicate one, and this matter in particular is far more ambiguous and controversial than my bald statement suggests. I cannot give it here the space which it deserves, but it may be worth stating in a crude and unargued way what I think the situation probably was. I believe (a) that the system of notation in common practical use was an early version of something like that of Alypius, based on δυνάμεις, and (b) that an alternative, quantitative system had perhaps been developed by the ἁρμονικοί, based on the calculations whose results were set out in the καταπύκνωσις diagrams. There is no evidence that any such system was in use among practical musicians, but the remarks of Aristoxenus in the passages at present under discussion suggest that one had been constructed as a tool of analysis by those whose views he is attacking. See R.P. Winnington-Ingram, 'The First Notational Diagram of Aristides Quintilianus', *Philologus* 117 (1973) 244 n. 2. In general on notation, see Michaelides *op.cit.* s.vv. parasemantike and onomasia, with the references given there, and H. Potiron, 'La notation grecque au temps d'Aristoxène', *Revue de Musicologie* 50 (1964) 222-5.
24. Implied apparently by *Macran op. cit.* 277.
25. The evidence is conveniently summarised in *Lippman op. cit.* ch. 1, and in *Burkert op. cit.* ch. 5 section 1.
26. *Ar. Metaph.* 1016b18, 1052b20, 1083b33. Cf. 1053b32 ff. and *An. Post.* 84b ad fin.
27. There is evidence that Aristotle was aware of some of the relevant contrasts and complications. See *Metaph.* 1053a14-16.
28. πυκνὸν δὲ λεγέσθω τὸ ἐκ δύο διαστημάτων συνεστηκὸς ὃ συντεθέντα ἑλαττον διάστημα περιέξει τοῦ λειπομένου διαστήματος ἐν τῷ διὰ τεσσάρων, *El.Harm.* 24.11-14. The πυκνὸν is, effectively, the

lower portion of an enharmonic or chromatic tetrachord. For an account of its nature and status, see 48.9-33.

29. As previously explained, it is impossible for them to be mathematically equal according to the Pythagorean system of ratios. See *Eucl. Sect. Can.* 16, and cf. the passages concerning Archytas and Philolaus cited at n.3 above.

30. See e.g. *El.Harm.* 19.23-9, *Anon. Bell.* 26.30, Aristox. ap. Plut. *De Mus.* 1134F.

31. *The Hibeh Papyri* ed. B.P.Grenfell and A.S.Hunt (London, 1906) part 1, no. 13. The papyrus itself dates from the mid-third century. The commonly accepted dating of its contents is based on W.Cronert, 'Die Hibehrede über die Musik', *Hermes* 44 (1909) 503-21. One of his main criteria is that of style, which he identifies as Isocratean: this seems to me doubtful. The other lies in the author's reference to the use of ἀρμονία (i.e. the enharmonic genus or style) by tragedians (col.1,16, col.2, 3-5). This is taken to prove a pre-Aristoxenean date, on the basis of *El.Harm.* 23.12-23. But that passage does not show, as generally supposed, that the use of the enharmonic had disappeared: it shows that what Aristoxenus regarded as the proper intervals of the enharmonic were in his time played inaccurately by most musicians. There is nothing here which entails that contemporary tragedians did not think of themselves as still employing the old forms: the new tendency is simply that of performers to raise the λίχανος when playing enharmonic music, thus pushing it in practice towards the form of the chromatic. A further piece of evidence for an early date is extracted from the reference to τὸ ὑποκείμενον σάνιδιον (col.2,13) by W.D.Anderson, *Ethos and education in Greek music* (Harvard, 1966) 149-50 and Appendix C. He takes this as a reference to the plank benches of the theatre in Athens: since the stone theatre of Dionysus was built in the mid-fourth century, and the seats were then no longer wooden, the fragment must pre-date the new building. Since the fragment makes no reference to Athens, let alone to any particular theatre, and since this ingenious interpretation of the phrase in question is scarcely proved, this suggestion can only charitably be described as speculative.

32. Col.2,1-6 plainly indicate that the author makes no distinction between διάτονος μουσική and χρώμα.

33. See especially *Rep.* 398c-400c.

34. E.g. Anderson op.cit. ch.1, Michaelides op.cit.s.v. ethos.

35. Aristides Quintilianus 21-2 (Meibom) = 18-20 (Winnington-Ingram, Teubner). See Winnington-Ingram, *Mode in ancient Greek music* 22-30.

36. Cf. Winnington-Ingram loc.cit., with his references, and Anderson op.cit. 18-19.

37. E.g. Hibeh Papyrus 1, 13 col.2,3-4. But cf. Plut.*De Mus.*1137E, *Quaest. conviv.* Bk.III, I, 11-12.

38. A certain indefiniteness about the distinctions between genera is suggested by the passage cited at n.32 above.

39. In the paper cited at n.6 above.

40. This seems to be an implication of *El.Harm.* 23.3-24, and is perhaps part of the position against which the author of the Hibeh Papyrus on music is arguing. See also Ar.Quint. 19 (Meibom) = 16.13 ff (Winnington-Ingram), and 133-4 (Meibom) = 110.28-111.27 (Winnington-Ingram). Cf. M.Vogel, *Die Enharmonik der Griechen* (Dusseldorf, 1963) with the discussion by Winnington-Ingram in *Die Musikforschung* 18 (1965) 60-4.

41. There is some ground for suggesting that much of the groundwork for the systematisation is that done by the Pythagoreans, drawn on surreptitiously by Aristoxenus. This question is too large to go into here, but with the more detailed mathematical sections of *El.Harm.* cf. Burkert op.cit. ch.5 section 2, and

R.P. Winnington-Ingram, 'Aristoxenus and the Intervals of Greek Music', *CQ* 26 (1932) 195-208.

42. See the account of Macran *op.cit.* 262-266.

43. In theorists from Aristoxenus onwards, the term μέλος may refer either to an actual melody, or to the legitimate series of notes which form a scale. The latter is in a sense an abstraction, constructed by identifying the note-types into which the individual sounds of the actual melody fall, and arranging them in an ordered sequence. For present purposes the ambiguity is unimportant: in fact whichever meaning we adopt the sense of the passage comes to much the same thing. The quarter-tone series cannot form the basis for any actual melody; but this means no more than that it cannot form the scale produced by setting down in order the note-types, actual or implied, which make up the legitimate set from instances of whose members given melodies are constructed. I am grateful to Professor Winnington-Ingram for pointing out to me the ambiguity in the term, and also for his helpful comments on other aspects of this paper, which he was kind enough to read in draft. I am encouraged by his general approval of the main lines of my argument, but errors of fact and judgement which remain are of course my own.